Structural Engineering Design Guide

• Introduction

General information on format and preparation of drawings, specifications, cost estimates and design analysis are covered in other chapters of the A&E Guide. Also Refer to the project specific Appendix "A" to determine the scope of A&E services and scheduled submission requirements.

The Structural portion of the project design shall be prepared and presented in a thorough and logical manner. This portion of the Guide covers specific technical requirements for typical Structural design submissions. It is not intended that the information provided in this chapter and other sections of the A&E Guide cover every situation, but it is to be followed where applicable. Situations not covered by this document should be approached with sound technical judgment and common sense.

• Communications

Direct communications with the structural reviewer is encouraged, if you have a question concerning a particular comment. This may avoid unnecessary re-submittal of plans and specifications due to a misunderstood comment. The reviewer's name, phone number and email address can be found on the comment sheets.

• Structural Engineering Design Requirements

The information contained in this section represents the issues and requirements that are the most misunderstood and troublesome to A&E firms under contract to the Atlantic Division.

• Selection of Structural Systems

Consider logical alternative foundations and framing methods when selecting an appropriate structural system. The following elements shall be evaluated and addressed:

- Quantify Total Life Cycle cost effectiveness of the structural system
- Review constructability
- Determine experience level of local contractors and labor force
- Verify availability and use of local materials.

In the analysis of material systems and framing the following should be avoided:

- Cold-formed steel members as primary structural steel framing.
- Metal stud backup for masonry veneered walls. When considered, stud backup shall be properly sized to limit deflection in the veneer. Design stud backup veneered walls as two component systems, applying a portion of the load to each component consistent with its relative stiffness.

- The Project Architect and Structural Engineer shall coordinate the design of cold-formed framing for all architectural uses (interior partitions, secondary framing members, support systems for architectural finishes, etc.).

Design Criteria

The National Technology Transfer Act of 1995 (Public Law 104-113) requires the Navy to adopt voluntary consensus standards whenever possible. Unified Facilities Criteria, UFC 1-200-01 "Design: General Building Requirements" provides guidance for the use of the 2000 International Building Code as the model building code for design and construction of Department of Defense facilities. A copy of this and other UFC's is available under the UFC Consolidated Index on the Engineering Innovation NAVFAC Criteria page at http://www.efdlant.navfac.navy.mil/criteria/documents/unified_facilities_criteria_new.htm Design the structural system to conform to the requirements of UFC 1-200-01 and all other applicable UFC, DoD, NAVFAC and other government criteria and guidance referenced in the Appendix "A".

Seismic Safety

All facilities, regardless of location, shall provide a minimum level of protection against the effects of a seismic event considering structural life safety, essential operational requirements, and the protection of capital investment. The seismic safety criteria for all Navy occupied facilities is provided by the NAVFAC letter of 02 Nov 2000, "Seismic Safety Criteria for Owned and Leased Buildings." A copy is available at http://efdlantit.efdlant.navfac.navy.mil/Seismic/Seismic_PDF/seismic-safety-criteria.pdf.

- **New Buildings**

  Use the requirements of UFC 1-200-01 for seismic design and detailing. The Army Corps of Engineers, TI-809-04, Seismic Design for Buildings, 31 December 1998 referred to in the UFC is available at http://www.hnd.usace.army.mil/techinfo/ti/809-04/ti80904.htm .

- **Existing Buildings**

  Executive Order 12941, Seismic Safety of Exiting Federally Owned or Leased Buildings, 1 Dec 1994 provides the basis for the seismic criteria for existing buildings. The Executive Order adopted ICSSC RP4, Standards of Seismic Safety for Existing Federally Owned or Leased Buildings, as the minimum standards. A copy of ICSSC RP-4 is available at the Building and Fire Research Laboratory of the National Institute of Standards and Technology in their BFRL Publication on-line library at http://fire.nist.gov/bfrlpubs/. These standards describe situations where evaluation and mitigation of unacceptable risk is required for existing facilities. They also include a list of exemptions to the minimum seismic requirements.

- The Navy has modified and extended the Executive Order requirements to existing Navy owned and leased facilities outside of the United States and its territories. Guidance is provided by the Naval Facilities Engineering Command, Seismic Hazards Mitigation Program for Facilities Outside of the Continental United States, its Territories and Possessions, March 2000. A copy of this document is available at http://www.lantdiv.navfac.navy.mil/pls/lantdiv/url/page/CI4_ENGINEERING_AND_DESIGN (Click on Guidance and Policy Tab).

In generally the evaluation and rehabilitation of existing buildings shall be according to the US Army Corps of Engineers, TI-809-05, Seismic Evaluation and Rehabilitation Guidelines for Upgrading Existing Buildings, Sept 88. This TI is available on the Internet at the following web site: http://www.hnd.usace.army.mil/techinfo/ti/809-05/80905page.htm .

- **Roof Design**

For new construction, a minimum slope of 1/2 inch per foot is preferred. Obtain roof pitch by sloping the structural members in lieu of using moisture bearing lightweight concrete fills, asphalt dry fills, or tapered board insulation.

For projects involving reroofing of existing roofs, the A&E shall provide calculations to show that the existing roof framing will support the new roof materials as well as the effects of all live and dead loads.

- **AISC Certification Requirements**

The purpose of the AISC Quality Certification Program is to confirm to the construction industry that a structural steel fabricating plant has the personnel, organization, experience, procedures, knowledge, equipment, capability and commitment to produce fabricated steel of the required quality for a given category of work. For information on the program go to **http://AISC.org**.

Use Category Sbd for conventional steel structures; use Category Cbd for complex steel structures (e.g., hangars). Consider the size and type of project as well as the quantity of steel fabricated when evaluating the necessity of specifying certified fabrication. Project with minimal amounts of steel fabrications need not satisfy this requirement.

- **High Strength Bolting**

The preferred method in all structural connections is high strength bolts, A325 or A490, in conjunction with Direct Tension Indicating washers (DTI's). It is recognized that the AISC requirement for fully tensioned bolts is only required in slip-critical connections, connections subject to direct tension and fully tensioned bearing connections. The benefit of using high strength bolts with DTI's in all connections is that it provides the best balance between design requirements, typical field bolt conditions, field installation practices and field installation quality assurance.

The use of high strength bolts with DTI's and proper installation techniques provides one of the best assurances that bolts will be tightened to the AISC requirements for fully tensioned bolts. The designer is assured that all bolts are essentially fully tensioned and at a minimum snug tight.

AISC requires that fasteners be protected from dirt and moisture at the job site. Inevitably, a certain amount of dirt and surface rust may appear on bolts prior to installation. The effect of dirt and surface rust on bolts makes tightening difficult. This greatly effects bolt tightening methods based on torque measurement (turn-of-nut, calibrated wrench, load indicator bolt) making them not as reliable. While dirt and rust will appear equally on bolts when DTI's are used, the required tension will not be sacrificed since the DTI's measure bolt tension and not torque. Similarly, the lack of bolt lubricant during field installation of bolts does not greatly effect required bolt tension when DTI's are used.

The preferred method of bolt installation by ROICC offices overseeing construction is the use of DTI's. Field inspection and field installation quality assurance is made easier with DTI's.

• Design Services

• Structural Basis of Design

Provide a narrative report on how the design concept satisfies the customer's requirements, meets criteria and is cost effective. Include statements on the following:

a) List a summary of the criteria upon which the structural design will be based. Include a statement of live loading to be used, to include floor loads, wind, snow, earthquake, etc., with references to justify.

b) Describe the type of construction selected and reason therefore, with capacity, dimensions, or other size criteria, and list of material selected with design strengths. Address **Selection of Structural System** as listed above.

c) Provide a narrative summary of the type of foundation to be used, method by which the allowable bearing values are to be determined, and maximum allowable bearing capacity for the foundations.

d) Describe the structural floor and roof systems proposed. Include a description of the lateral force resisting system with appropriate materials and dimensions. Clearly describe the load path to the foundation for the lateral force resisting system.

e) When appropriate provide a statement of any special considerations that affect the design (e.g., "superflat floors" for high stacking warehouses, special corrosion resistance requirements, retractable roofs, crane or monorail, etc.).

• Structural Calculations

Provide structural calculations for the main framing systems and all components (beams, columns, walls, foundations, slabs, bracing, diaphragms, etc.) of the project considering all design loads and criteria. Design for lateral forces shall not assume wind load governs. Designs must incorporate seismic and wind provisions and the appropriate details for each.

Computer generated calculations shall identify the program source. The schematic models used for input shall show, as a minimum, nodes/joints, element/members, materials/properties, and all loadings, induced settlements/deflections, etc., and a list of load combinations. Results shall include an output listing for maximum/minimum stresses/forces and deflections for each element and the reactions for each loading case and combination.

• Design Submittals

• 35% Design Development Submittal

• Basis of Design

Submit the completed Basis of Design as defined above.

- **Drawings**

  As a minimum submit the following drawings developed in sufficient detail to support items outlined in the Basis of Design:

  a) Foundation Plan(s): Include for all structures, showing dimensions, arrangements, elevations, locations referenced to a column line grid system, type of foundation and foundation obstructions. Include the layout of all slabs, footings, piers, grade beams, piles, etc. showing special construction features, that have a significant impact on the design and cost. Include on the drawing all relevant design data (live loads, applicable codes and soil bearing, or pile bearing capacity).

  b) Framing Plan(s): Include for all floors and roofs, showing dimensions, elevations, column locations and numbering system, and overall sizes of major members and components. Show the layout of beams, joists, stringers, etc. Include on the drawing all relevant design data, design methods and general notes.

  c) Structural Elevations: Show general sizes, location and arrangement of all significant features of the vertical framing system. Include the layout of columns, walls, beams, etc.

- **Calculations**

  Calculations shall be complete in sufficient detail to support the items outlined in the Basis of Design and indicated on the drawings.

- ## 100% Prefinal Submittal

  - **Basis of Design**

    Supplement the basis of design discussions as necessary and respond to reflect previous government review comments. Resubmission of corrected Basis of Design is not required.

  - **Drawings**

    Drawings shall be 100% complete minus signatures.

  - **Calculations**

    Calculations shall support all items and details outlined on the drawings and specifications. Calculations shall be revised as required to reflect resolution of all previous government review comments. At this stage the analysis shall be 100% complete.

- ## Final Submittal

  Submit complete and corrected drawings, specifications and design analysis.